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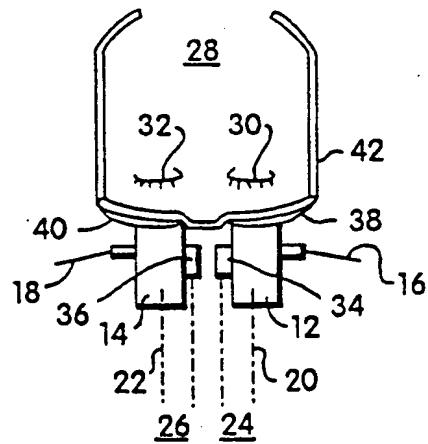
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International Bureau



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(71) Applicant: LUXTEC CORPORATION [US/US]; Technology Park, P.O. Box 225, Sturbridge, MA 01566-0225 (US). (72) Inventors: CLARK, Bernard ; The Sunderland, RD 2, Rte. 7A, Arlington, VT 05250 (US). WU, Dau ; 44 Gilmore Road, Southboro, MA 01772 (US). (74) Agents: GAGNEBIN, Charles, L., III et al.; Weingarten, Schurgin, Gagnebin & Hayes, Ten Post Office Square, Boston, MA 02109 (US).		Published <i>With international search report.</i> <i>With amended claims.</i>	

(54) Title: OPTICAL SYSTEM WHICH ALLOWS COINCIDENT VIEWING, ILLUMINATING AND PHOTOGRAPHING



(57) Abstract

A binocular surgical loupe (12, 14, 84, 86, 130, 132) which enhances the illumination of the viewed field while avoiding flare effects of illuminating light within the loupe optics. The binocular system utilizes circularly polarized illumination and viewing to prevent flare effects and additionally enhances the illumination of the field of view by utilization of the illumination source waste beam that results from the presence of a beam splitter in the illumination path within the loupe. In addition, a camera system (80, 142) is provided which permits remote viewing of the user's field of view. In one embodiment the camera and view paths include separate, identical zoom lenses (98, 112) which are synchronously controlled so that the fields of illumination and view are kept coextensive. In another embodiment for a binocular loupe, the loupe optics for one eye combines illumination and viewing functions while the loupe for the other eye combines camera and viewing functions.

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- 1 -

OPTICAL SYSTEM WHICH ALLOWS COINCIDENT VIEWING,  
ILLUMINATING AND PHOTOGRAPHING

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to optical loupes utilized in surgical and other procedures for providing magnified viewing and illumination of fields of interest to a surgeon or other user. Such systems typically include first and second loupes which permit binocular viewing with magnification of a region of interest. Illumination has been provided in the past by a separate illumination source, typically located and supported in the forehead region of the surgeon.

More recently, and as represented in co-pending U.S. Application Serial No. 07/327,644, filed March 23, 1989, the illumination function is combined into the viewing loupe in order to avoid the shadow cast in the field of view by a light source located away from the viewing axis. In such combined optics it is important to prevent the high intensity illumination, passing through the loupe from the illumination source, from creating a flare effect, typically from a brightness at the interface of the loupe beam splitting optics.

At the same time, because of the attenuation in loupe beam splitter optics, some illumination is lost both in the path of illumination from the source and in the path of viewing by the operator of the field of view. It is important that the optics minimize attenuation and maximize the perceived illumination of the field of view while avoiding flare effects.

It is additionally desirable to provide a video image of the user's field of view to provide offsite display and control of that field of view without interfering with the user's procedures or views.

- 2 -

BRIEF SUMMARY OF THE INVENTION

In accordance with the teaching of the present invention a binocular loupe system is provided for surgical or related usages. The loupe system provides 5 illumination of the field of view along the viewing axis and includes optics which enhance the illumination and brilliance of the field of view while minimizing the effects of flare resulting from the presence of intense illuminating radiation passing through the optics which 10 also lie in the view path of the loupe. Additional embodiments provide video viewing of the field of view and remote presentation of the image along with synchronized remote control of illumination and viewing optics for the view scene. In an alternative embodiment a video viewing 15 system is integrated into a viewing loupe of a binocular loupe system while the other loupe provides on axis illumination in combination with operator viewing.

BRIEF DESCRIPTION OF THE DRAWING

20 These and other features of the present invention are more fully set forth below in the solely exemplary detailed description and accompanying drawing of which:

Fig. 1 is a diagrammatic view of a binocular loupe system according to the present invention;

25 Fig. 2 is an internal view of a representative loupe of the binocular loupe system of Fig. 1;

Fig. 3 is a diagrammatic view of a video camera system in use alongside a binocular loupe;

30 Fig. 4 is an internal view of the video camera system of Fig. 3;

Fig. 5 is a diagrammatic view of a binocular loupe system having integrated into one loupe a video camera system; and

35 Fig. 6 is an internal view of the loupe and associated camera system of Fig. 5.

DETAILED DESCRIPTION

The present invention contemplates a surgical loupe system in which the optical design provides for enhanced brilliance in the operator's view and provides a video output of the field of view of the operator.

In accordance with one embodiment of the invention in Fig. 1, a binocular viewing system comprises first and second loupes 12 and 14. Illumination is delivered through optical fibers 16 and 18 for each loupe 12 and 14. Optics within the loupes 12 and 14 direct the illumination provided by the fibers 16 and 18 along respective output axis 20 and 22 to illuminate respective fields of view 24 and 26. The fields of view 24 and 26 will coincide at the normal operator viewing distance. An operator 28 views the fields of view 24 and 26 through respective eyes 30 and 32 aligned to view along the axes 20 and 22 through loupes 12 and 14. Illumination provided from the fibers 16 and 18, which would otherwise be waste illumination, is captured by the loupe optics and directed towards the respective fields of view 24 and 26 by optical subassemblies 34 and 36. The loupes 12 and 14 and associated optics illustrated in Fig. 1 are substantially identical and are mounted for ease of operator use either on a separate headband or, as illustrated in Fig. 1, directly in lenses 38 and 40 of a pair of eyeglasses set in a frame 42 and custom adapted to the surgeon's needs. In so customizing the eyeglasses, the loupes 12 and 14 are fitted into the glass lenses 38 and 40, typically by screwing them into apertures formed in the lenses in locations custom designed to match the viewing direction of the surgeon's eyes 30 and 32 while permitting peripheral viewing by the surgeon through the lenses 38 and 40 by moving his eyes.

The loupes 12 and 14 are substantially identical although they may be provided in right and left hand

- 4 -

forms. Fig. 2 illustrates the internal structure of each loupe 12 and 14. As shown there a housing 50 is provided with a beam splitting optical cube 52 with a beam splitting interface 54 mounted within the housing 50. The 5 beam splitting interface 54 preferably provides 50% reflection and 50% transmission which provides optimal scene and viewing brightness.

The optical fibers 16 or 18 which supply illumination from a source 56 are mounted through a 10 support 58 to the housing 50 to direct illumination through a lens system 60 and circular polarizing filter 62 for reflection from a first surface of the beam splitting interface 54 outward through a further, objective lens system 64 to illuminate the field of view 24 or 26. That 15 portion of the radiation, typically 50%, which passes through the beam splitting interface 54 extends onward through the housing 50 to a reflector 66 within the subassemblies 34 or 36 from which it is directed generally to illuminate the field of view 24 or 26 at the location where the surgeon or other operator is to view it. 20

Rays from the illuminated image returning from the field of view 24, 26 pass back through lens 64 to optical interface 54 where it is transmitted, in part, through the first to the second surface of the interface 54 to a 25 circular polarizing filter 68 and a Pechan/Schmidt roof prism 70 on through eyepiece optics 72 to an eye 30, 32 of the viewer.

The polarizing filters 62 and 68 provide circular polarization which attenuates the radiation only by 20% 30 while transmitting 80%. The dimensions of the path between the polarizing filters 62 and 68 for light which causes perceivable brightness or flare at the interface 54 within the cube 52 is such that all such illumination is attenuated by the combined polarizations of the filters 62 and 68. Scattering by objects within the field of 35 view 24, 26, however, causes the returning illumination to

- 5 -

loose a defined polarization such that the filter 68 is relatively ineffective in attenuating that illumination which in turn passes through the optics 70 and 72 to the viewing eye 30, 32.

5       The prism 70, provides an erratic image and further lengthens the optical path in order to achieve a desired focal length for the telescope formed by objective lens system 64 in combination with eyepiece lenses 72. The lens system 60 is provided in order to optimize the 10 available illumination from the optical fiber 16, 18 so that it illuminates the same field of view 24, 26, or portion thereof, as seen by the viewer's eye 30, 32.

15      It is desirable in many applications to provide a remote image of the field of view observed by the surgeon or other operator during whatever procedure the surgeon or operator is engaged in. Such viewing can be for purposes of remote monitoring by assisting personnel or for use in teaching. It may also be useful for providing video recording of procedures. For such purposes, according to 20 the present invention, an optical camera system 80, as illustrated in Fig. 3, is attached to a headband 82 of the type known in the art and securely fitted about the head of the operator in such position that it typically lies between loupes 84 and 86 which are positioned, either by 25 eyeglass supports or additionally supported by the headband 82, to permit the operator's eyes 88 and 90 to view respectively therethrough. Loupes 84, 86 may be of the design described above, other design, or may be omitted entirely.

30      The structure of the camera system 80 is illustrated more fully below with respect to Fig. 4. As shown there the camera 80 includes a housing 90 having therein a charge couple device (CCD), video sensor chip 92 and amplifier/driver pc board 93. Chip 92 responds to the 35 light from a field of view 94 after passing through a beam splitter 96, zoom lens 98 and infrared filter 100 to

- 6 -

provide a corresponding video signal that is amplified on the board 93 to drive an output cable 104 to a controller 125 and monitor 126 or other utilization device.

The field of view 94 is illuminated by light from an optical fiber 106 through a lens 108 and reflector 110 which positions the illumination to pass through a zoom lens 112 to be reflected by a reflector 114 from which it is reflected off the beam splitter 96 to travel the same optical axis as viewed by the chip 92 toward the field of view 94. Polarizing filters 116 and 118 may be provided as described above with respect to Fig. 2 in the path of illumination from the cable 116 and in the viewing path after passing through the beam splitter 96 in order to eliminate from the image processed by the chip 92 all flare from the beam splitter 96 resulting from its illumination by light from the cable 106. An absorber 120 may additionally be provided so that all radiation passing through the beam splitter 96 from the illuminating light in cable 106 is absorbed and not permitted to reflect within the housing 90 causing further undesirable optical or flare effects. A subassembly such as described above may alternatively be provided to make use of this waste beam.

The zoom lenses 98 and 112 are typically identical and are coupled either mechanically or electrically by a coupling 122 to vary their focal lengths together. A focus control 124 is provided remotely, typically at the location of viewing monitor 126 for the video image transmitted by the processor chip 92. The use of coordinated zoom lenses 98 and 112 permits the region of illumination to track in size the region of view seen by the video sensor chip 92. This in turn provides optimal utilization of the incident illumination.

A microphone 128 is mounted on a suitable surface of the housing 80, such as on the front as shown, and its output is coupled into the cable 104 through the

- 7 -

amplifier/driver board 93. The audio discussions during the operation or procedure are thus remotely transmitted to controller 125 where they are reproduced by a speaker 129.

5 Alternatively, a video camera may be incorporated into a binocular loupe system as illustrated in Figs. 5 and 6. As shown in Fig. 5 first and second loupes 130 and 132 are provided and supported by a means 134 which may include either eyeglass lenses and/or frames or a  
10 separate headband as desired. The loupes 130 and 132 are positioned, as described above, in coordination with the operator's eyes 136 and 138 to permit optimal viewing of a field of view 140. One of the loupes, shown here as loupe 132, has associated with it a video camera 142 the  
15 design of which, and the associated loupe 132, are more fully described below in Fig. 6. The other loupe 130 typically is of the design illustrated above in Fig. 2 with or without a waste beam utilization subassembly 34, 36 and is supplied with illumination from an optical fiber 144. As thus shown both loupes 130 and 132 provide  
20 viewing by the operator of the field of view 140. The loupe 130 is additionally constructed to provide illumination along the same axis as is used for viewing while the loupe 132 is constructed to provide video  
25 sensing of the image along the same axis as used for viewing.

With respect to Fig. 6 the details of the loupe 132 and associated camera 142 are more fully described. As shown there, viewing of the field of view 140 is accomplished along an optical axis which passes through an  
30 objective lens 150, beam splitter 152, Pechan/Schmidt prism 154 and objective lens 156. The beam splitter 152 has a beam splitting interface 158 which provides an appropriate percentage of transmission and reflection depending upon the sensitivity of the video camera and the  
35 matching transmission of the companion loupe 130. Typical

- 8 -

transmission reflection percentages would be 50/50. The light reflected by the beam splitting interface 158 is directed upwards where a reflector 160 redirects it within the video camera portion 142 through an optical system 162 and infrared filter 164 to a video sensor chip 166, also typically a charge coupled device (CCD), to an amplifier/driver 167. The video sensor 166 converts the received image to a video signal which is applied as an output on a cable 168 by amplifier/driver 167 to a video monitor or otherwise as desired. A front mounted microphone 170 is also provided and its output is applied through amplifier/driver 167 to the cable 168.

In this manner the structure of Figs. 5 and 6 provides both on axis viewing as well as video photography through a single pair of binocular loupes 130 and 132.

It is to be noted that for weight minimization in the optical designs above plastic lenses are typically utilized along with other lightweight materials. Specific structures for embodying the structure and concepts illustrated above, or different combinations of them are considered to be within the scope of the invention which is solely limited in accordance with the following claims.

- 9 -

CLAIMS

1. A surgical loupe comprising:  
a housing;  
a beam splitter supported within said housing and  
responsive on a first surface thereof to illumination from  
5 a source for directing said illumination toward a field of  
view;  
reflector means responsive to said illumination from  
said source passing through said beam splitter from said  
first to a second surface for reflecting that illumination  
10 toward said field of view;  
operator viewing optics positioned to view said  
field of view through said beam splitter along an axis  
substantially angled to an axis of said illumination from  
said source.
- 15 2. The loupe of claim 1 wherein said beam splitter  
provides 50/50 beam splitting.
- 20 3. The loupe of claim 1 wherein said beam splitter is  
an interior surface of an optical cube.
4. The loupe of claim 1 wherein said operator viewing  
optics includes a path lengthening prism.
- 25 5. The loupe of claim 4 wherein said prism includes a  
Pechan/Schmidt prism.
6. A binocular loupe comprising:  
a housing having viewing optics for respective  
30 operator eyes wherein each said viewing optics comprise  
the loupe of claims 1, 2, 3, 4 or 5.
- 35 7. The binocular loupe viewing system of claim 6  
further including means for supporting said loupes in  
position for operator viewing therethrough.

- 10 -

8. The system of claim 7 wherein said supporting means includes:

an eyeglass frame and lenses; and  
means for mounting said loupes in the lenses of said  
5 eyeglass frame.

9. A surgical camera comprising:

a first variable focal length lens positioned to  
receive illumination from a source;  
10 beam splitter means responsive on a first surface  
for receiving illumination from said source after passage  
through said first variable focal length lens and for  
directing said illumination toward a field of view;  
a second variable focal length lens positioned to  
15 receive illumination from said field of view after passing  
through said beam splitter means from said first to a  
second surface thereof; and  
video sensing means responsive to illumination from  
said field of view through said second variable focal  
length lens for producing a corresponding video output  
20 signal.

10. The camera of claim 9 further including means for  
coupling said first and second variable focal length  
25 lenses whereby the field of view illuminated by said  
source varies with the field of view received by said  
video sensing means.

11. The camera of claim 10 wherein said first and second  
30 variable focal length lenses are substantially of the same  
zoom lens design.

12. The camera of claim 9 further including:  
first polarizing means for providing a predetermined  
35 polarization in the illumination applied to said first  
surface of said beam splitter means; and

- 11 -

second polarizing means for providing a predetermined polarization in the illumination from said field of view passing through said beam splitter means whereby flare from said beam splitting means resulting from illumination thereof by said source is attenuated while a substantial portion of the illumination from said field of view is transmitted.

- 5 13. The camera of claim 9 further including:  
10 means for mounting said first and second variable focal length lenses in side by side relationship whereby a variation in one produces a variation in the second of a corresponding degree;  
15 a reflector placed to reflect illumination passing through said first variable focal length lens from said source for application to said first surface of beam splitter means.
- 20 14. The camera of claim 9 further including means for supporting said camera between an operator's eyes.
15. The camera of claim 14 wherein said supporting means includes a headband.
- 25 16. The camera of claim 14 wherein:  
one or more surgical loupes are provided for operator viewing from one or both operator eyes; and  
means are provided for supporting said one or more loupes adjacent to the camera of claim 14.
- 30 17. A combination binocular surgical loupe and camera comprising:  
first and second housings each having operator viewing optics and positioned for operator viewing therethrough of respective first and second fields of view;  
35 first and second beam splitter means within said first and second housings respectively and positioned for

- 12 -

providing operator viewing therethrough of illumination from said first and second fields of view through a first to a second surface of said beam splitter means respectively;

5 means for applying illumination from a source to the first surface of said first beam splitter means for reflection toward said first field of view;

10 means for receiving illumination from said second field of view within said second housing for reflection from said first surface of said second beam splitter means for providing video sensing of that illumination to provide a video output signal representative of said second field of view.

15 18. The combination of claim 17 further including means for supporting said first and second housings for operator viewing therethrough.

20 19. The combination of claim 17 wherein said first and second operator viewing optics include a path length expanding prism.

25 20. The combination of claim 17 wherein said first and second beam splitter means include a beam splitting interior surface of respective first and second optical cubes.

21. The combination of claim 17 further including:  
30 a first polarizing filter operative to provide a predetermined polarization on the illumination from said source applied to the first surface of said first beam splitter means; and

35 a second polarizing filter operative to provide a predetermined polarization on the illumination passing through said first beam splitter means to said operator to attenuate flare in said beam splitting means caused by the illumination from said source.

WO 91/06025

- 13 -

22. The combination of claim 21 wherein said first and second polarizing filters provide circular polarization.

23. The apparatus of claims 9 or 17 wherein said video sensing means includes a charge coupled device (CCD).  
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24. The apparatus of claim 23 further including a filter for the illumination applied to said video sensing means.

10 25. The apparatus of claims 9 or 17 further including means for sensing audio.

## AMENDED CLAIMS

[received by the International Bureau on 08 April 1991 (08.04.91);  
original claims 1-25 replaced by amended claims 1-25 (5 pages)]

1. A surgical loupe comprising:
  - a housing;
  - a source for providing illumination along a first axis to illuminate a field of view;
  - 5 a beam splitter supported within said housing and having a beam splitter interface for reflecting a first portion of said illumination and for transmitting therethrough a second portion of said illumination, said beam splitter interface reflecting said first portion of said illumination from said source toward the field of view;
  - 10 reflector means responsive to said second portion of said illumination from said source transmitted through said beam splitter interface for reflecting said second portion of said illumination toward field of view;
  - 15 operator view optics defining a viewing axis for view in the field of view through said beam splitter, said first axis of said illumination from said source.
- 20 2. The loupe of claim 1 wherein said beam splitter provides 50/50 beam splitting wherein said first portion of said illumination reflected by said beam splitter interface is 50 percent and said second portion of said illumination transmitted by said beam splitter interface is 50 percent.
- 25 3. The loupe of claim 1 wherein said beam splitter comprises an optical cube having an interior surface operative as said beam splitter interface.
- 30 4. The loupe of claim 1 wherein said operator viewing optics includes a path lengthening prism.

5. The loupe of claim 4 wherein said prism includes a Pechan/Schmidt prism.

6. A binocular loupe viewing system comprising:  
5 a housing having viewing optics for respective operator eyes wherein each said viewing optics comprise the loupe of claims 1, 2, 3, 4 or 5.

7. The binocular loupe viewing system of claim 6.  
10 further including means for supporting said loupes in position for operator viewing therethrough.

8. The system of claim 7 wherein said supporting means includes:  
15 an eyeglass frame and lenses; and means for mounting said loupes in the lenses of said eyeglass frame.

9. A surgical camera comprising:  
20 a first variable focal length lens positioned to receive illumination from a source;  
beam splitter means having a beam splitter interface for reflecting a first portion of said illumination and for transmitting therethrough a second portion of said illumination from said source, after passage through said 25 first variable focal length lens, toward the field of view;  
a second variable focal length lens positioned to receive illumination from said field of view after passing through said beam splitter means from said first to a second surface thereof; and  
30 video sensing means responsive to illumination from said field of view through said second variable focal length lens for producing a corresponding video output signal.

10. The camera of claim 9 further including means for coupling said first and second variable focal length lenses whereby the field of view illuminated by said source varies with the field of view received by said video sensing means.
11. The camera of claim 10 wherein said first and second variable focal length lenses are substantially of the same zoom lens design.
12. The camera of claim 9 further including:  
first polarizing means for providing a predetermined polarization in the illumination applied to said first surface of said beam splitter means; and  
second polarizing means for providing a predetermined polarization in the illumination from said field of view passing through said beam splitter means whereby flare from said beam splitting means resulting from illumination thereof by said source is attenuated while a substantial portion of the illumination from said field of view is transmitted.
13. The camera of claim 9 further including:  
means for mounting said first and second variable focal length lenses in side by side relationship whereby a variation in one produces a variation in the second of a corresponding degree;  
a reflector placed to reflect illumination passing through said first variable focal length lens from said source for application to said first surface of beam splitter means.
14. The camera of claim 9 further including means for supporting said camera between an operator's eyes.

-17-

15. The camera of claim 14 wherein said supporting means includes a headband.

16. The camera of claim 14 wherein:

5 one or more surgical loupes are provided for operator viewing from one or both operator eyes; and means are provided for supporting said one or more loupes adjacent to the camera of claim 14.

10 17. A combination binocular surgical loupe viewing system and camera comprising:

first and second housings each having operator viewing optics and positioned for operator viewing therethrough of respective first and second fields of view;

15 first and second beam splitter means within said first and second housings respectively and positioned for providing operator viewing therethrough of illumination from said first and second fields of view through a first to a second surface of said beam splitter means respectively;

20 means for applying illumination from a source to the first surface of said first beam splitter means for reflection toward said first field of view;

means for receiving illumination from said second field of view within said second housing for reflection from said first surface of said second beam splitter means for providing video sensing of that illumination to provide a video output signal representative of said second field of view.

30 18. The combination of claim 17 further including means for supporting said first and second housings for operator viewing therethrough.

35 19. The combination of claim 17 wherein said first and second operator viewing optics include a path length expanding prism.

-18-

20. The combination of claim 17 wherein said first and second beam splitter means include a beam splitting interior surface of respective first and second optical cubes.

5

21. The combination of claim 17 further including:

10 a first polarizing filter operative to provide a predetermined polarization on the illumination from said source applied to the first surface of said first beam splitter means; and

15 a second polarizing filter operative to provide a predetermined polarization on the illumination passing through said first beam splitter means to said operator to attenuate flare in said beam splitting means caused by the illumination from said source.

22. The combination of claim 21 wherein said first and second polarizing filters provide circular polarization.

20 23. The apparatus of claims 9 or 17 wherein said video sensing means includes a charge coupled device (CCD).

24. The apparatus of claim 23 further including a filter for the illumination applied to said video sensing means.

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25. The apparatus of claims 9 or 17 further including means for sensing audio.

1/3

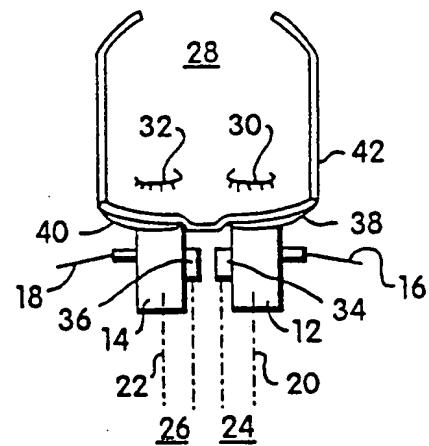


Fig. 1

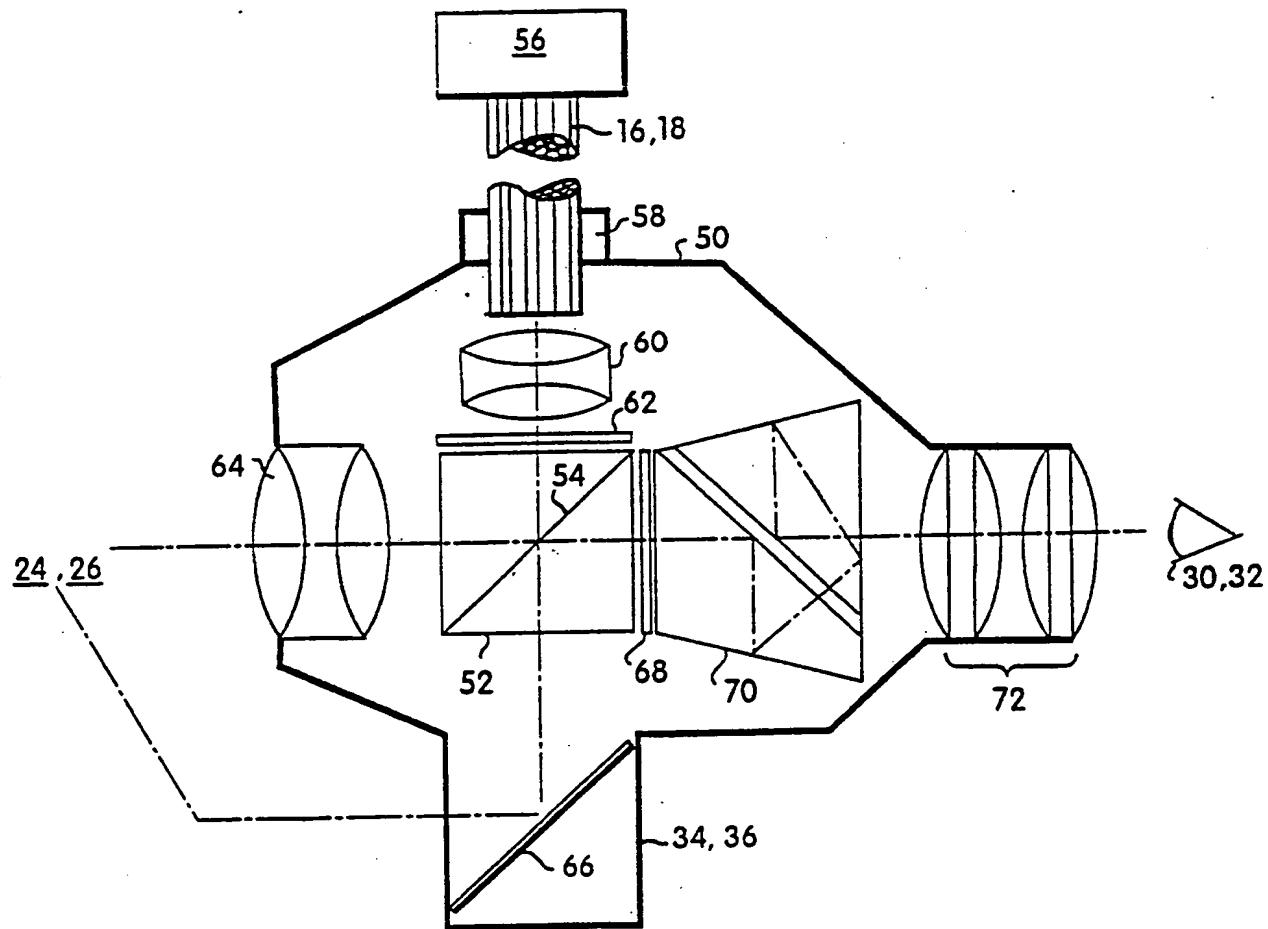


Fig. 2

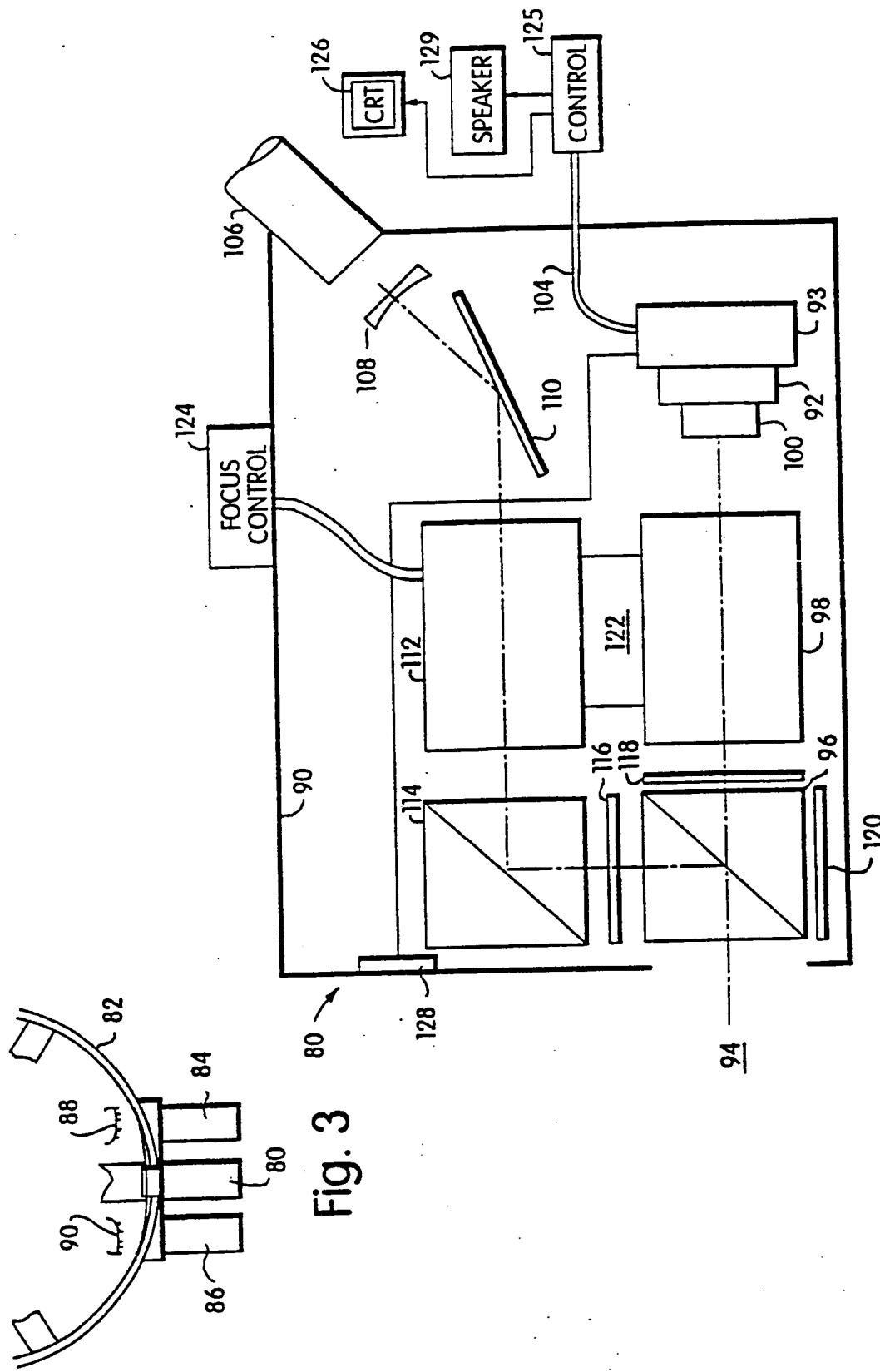


Fig. 3

Fig. 4

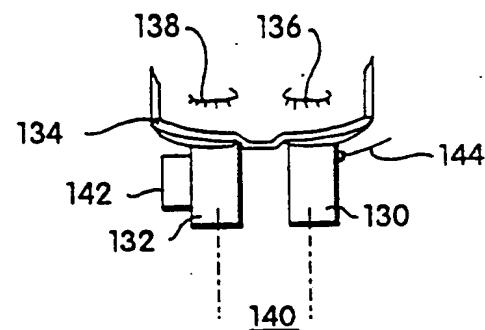
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Fig. 5

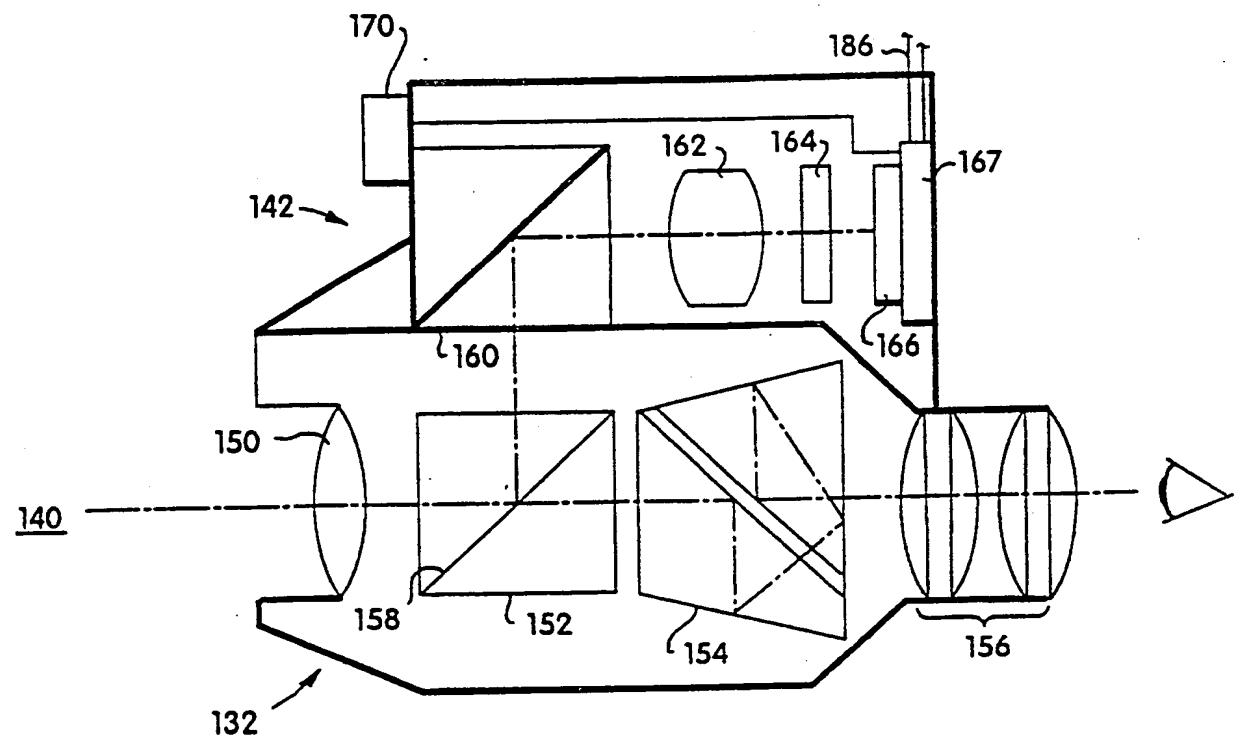


Fig. 6

# INTERNATIONAL SEARCH REPORT

International Application No. PCT/US90/05830

## I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) <sup>1)</sup>

According to International Patent Classification (IPC) or to both National Classification and IPC  
 IPC (5) G02B 21/06, 21/22, 23/18, 25/02; C03B 17/00, 17/17, 17/48  
 U.S. Cl. 350/145, 547, 236, 502, 399, 527; 351/158; 358/93, 225

## II. FIELDS SEARCHED

Minimum Documentation Searched <sup>4)</sup>

Classification System <sup>5)</sup>	Classification Symbols
U.S.	350/145, 146, 547, 548, 545, 236, 237, 502, 527, 399 351/235, 158; 358/93, 225
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>6)</sup>	

## III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>14)</sup>

Category <sup>7)</sup>	Citation of Document, <sup>15)</sup> with indication, where appropriate, of the relevant passages <sup>16)</sup>	Relevant to Claim No. <sup>18)</sup>
X A	US, A, 3,066,569, (McDonald), 04 December 1962, See entire document	1-2 3-8, 16-22, 23-25
A	US, A, 3,586,414, (Schultz), 06 June 1971	1-8, 16-22 23-25
A	US, A, 2,111, 187, (Keeler), 15 March 1938	1-8, 16-22 23-25
A	US, A, 4,516,190, (Kloots), 07 May 1985  (con't)	1-8, 16-22 23-25

\* Special categories of cited documents: <sup>15)</sup>

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

## IV. CERTIFICATION

Date of the Actual Completion of the International Search <sup>17)</sup>

24 January 1991

Date of Mailing of this International Search Report <sup>18)</sup>

20 FEB 1991

International Searching Authority <sup>19)</sup>  
ISA/US

Signature of Authorized Officer <sup>20)</sup>

*Jon W. Henry*